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A DISCUSSION OF "NOTES ON PRINCIPLES OF OIL ACCUMULATION" BY A. W. McCOY[1]

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In many ways this is one of the most interesting articles on the accumulation of oil that has appeared. I have long held many of the conclusions reached by Mr. McCoy in this paper, and it is a great pleasure to find these ideas corroborated by his experiments, which have been cleverly conceived and executed. It is unnecessary to reiterate the good points of the paper. It will be more useful to call attention to some of the more doubtful conclusions, in the hope that further study by McCoy and others may clarify these points.

Origin of oil.—The first experiment shows that liquid oil may be formed by the deformation of oil shale which previous to deformation contained only solid organic materials. McCoy states that "no appreciable amount of heat was developed." It seems to me impossible to deform the steel cylinders and to crush and shear the inclosed shale without causing an appreciable increase in temperature. If the experiments had been carried out in cylinders under water and if the temperature of the latter had been measured after the completion of the experiment, I believe McCoy would have found that there had been a material loss of energy in the form of heat. Shale is notoriously a poor conductor of heat. Therefore there must be a material rise in temperature along every plane of shear. As stated by McCoy, differential movement in shales probably is an important cause of the alteration of solid organic matter into oils. However, it is probably heat rather than pressure which causes this alteration. Heat is a common cause of the dissociation of various molecules. Pressure never has been known to split a molecule of any kind; nor has mere "mechanical energy." It will require an entirely new concept of the molecule to assume that a mechanical shear can cut a molecule. Only vibratory forces, like heat, light, electricity, and subatomic radiations are now thought to be capable of penetrating molecules. The mechanical energy of McCoy's experiment must have been transformed into one of these other forms of energy before it could split the molecules of organic solids.

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[1] *Jour. Geol.*, XXVII (1919), 252–62.

The formation of oil is a process which results in a great increase in the volume of the original solid material, which is converted into new solids, liquids, and gases. Pressure therefore is a condition which might be expected to retard rather than accelerate the process. In fact, the distillation experiments by Engler have shown that pressure retards the thermal dissociation of fats. The principal effect of pressure in this connection is to cause an inward shift in the point of splitting within the solid organic molecules. High pressure causes the splitting to take place farther from the surface of the molecules, resulting in the formation of less gas and coke and of more of the intermediate or liquid products. The same phenomenon also appears to rule the operation of the high-pressure stills of cracking plants, decreasing the amount of gas and residue in the product, and increasing the amount of gasoline, and under certain conditions increasing the yield of kerosene. Therefore high pressure in the rocks probably is a useful and essential condition for the formation of oil. It is not, however, the main cause of the formation of oil. There is nothing in this experiment to indicate that heat is not the principal agent that splits solid organic molecules into gases, oils, and carbon-rich residues such as asphalt.

A slight increase in temperature may be enough to initiate the process, after which the release of the endothermic heat of formation evolved by the splitting of the first molecules would increase the temperature of adjacent molecules. Thus, when once initiated by any cause, the process of thermal dissociation of solid matter into oil, gas, and black residue would tend to perpetuate itself and to increase, like spontaneous combustion, as long as there was an abundant supply of endothermic organic matter present.

There is reason to doubt that the known types of oil shale had anything to do with the formation of oil. Many of these shales, as in Scotland, New Brunswick, and New South Wales, have undergone such severe deformation that if their contents were capable of being converted into crude oil by such means, it is hard to understand why they have not all been completely converted. Yet in these fields there is no indication that any of the oil-shale has been altered into crude oil. Reagents will not extract more than a trace of oil from them. The oils obtained from them by distillation consist largely of unsaturated hydrocarbons which could not be converted into the better types of natural crude oils except by hydrogenation. Hydrogenation seems impossible in nature. Moreover, the collection of numerous analysis by Hoefer shows that the oil shales of various ages exhibit an increasing ratio of carbon to hydrogen in the samples from older rocks, indicating that the course of metamorphism of oil shales is very similar to that of coal, and that the organic matter in these shales tends to become harder and richer in carbon with the passage of time. There is some suggestion that the oil shales of Colorado and Utah and the Cannel coals of Kentucky will be found to be of this same general type. The substances in shale which have been converted into crude oils very likely are of a nature somewhat different from the organic matter in the types of oil shales that have been studied. The nature of this difference is a problem for future investigation. This point may be determined by distilling unaltered marine oil shales, preferably of the Late Tertiary, and by studying the decomposition of the fats and waxes of modern organisms.

Oil migration in wet sand.—Mr. McCoy's third experiment shows rather clearly that under ordinary temperatures oil will not migrate away from the larger pores in a sand under the influence of gravity aided by rather strong circulation of water. The capillary forces involved are strong enough to hold the oil in the larger pores against the influence of gravity and water circulation.

It would be very interesting to have this experiment repeated under the temperatures that prevail at depths of a few miles, where capillary forces are greatly reduced. The viscosity of the oil also is reduced. A useful point has been established by

McCoy in showing that under common surface temperatures a comparatively vigorous circulation of water will not remove oil from the larger pores of the sand. It does not follow, however, that water circulation could not do this at depths of two or three miles, which does not exceed the probable thickness of strata that formerly covered many oil sands. Further experiments under appropriate higher temperatures are needed to show that gravity alone could not produce anticlinal accumulation in sands buried under a few miles of rock.

Anticlinal accumulation.—Mr. McCoy appears to believe that the lateral migration of oil in sands is of minor importance. He believes that the anticlinal accumulation, which characterizes most fields, is due primarily to migration along nearly vertical shale joints, which are most abundant theoretically on the crests and limbs of anticlines.

There is an asymmetrical distribution of oil in the Cushing and Yale fields, Oklahoma, and in other places where the basin-ward limbs carry the most oil, and carry oil to the lowest structural elevations. This indicates that lateral migration up the slope of sandbeds is an important element in anticlinal accumulation. On the other hand, the frequent distribution of oil in various sands, one above the other, and all above the probable source, as in the Wyoming domes, indicates the importance of joints across the shales. The relation to faults of the principal fields in Kentucky and northern Louisiana bears similar testimony.

The accumulation of oil in the sand of the Ranger field, which is "dry" outside of the producing territory, also suggests the inadequacy of lateral migration in the sands. The occurrence of oil in fractured chert on top of the Santa Maria anticline in California must have been due wholly to migration along nearly vertical crevices, since it would be impossible for oil to move laterally through the hard, dense, unfissured chert on the lower parts of the anticline. Wells drilled on the flanks of this anticline showed neither oil nor water when they passed through the chert horizon.

In spite of these interesting experiments it seems that the time has not yet come to abandon wholly our previous ideas that an important part of anticlinal accumulation is due to migration up the slope of the sand. The experiments are important in showing the difficulty or impossibility of such migration under the low temperatures of very shallow depths. The experiments by McCoy show that we should give more thought to the importance of anticlinal crevices in shale.